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(58) Field of search
B1S

(54) **Apparatus for replenishing a melt**

(57) Apparatus for replenishing a melt while a crystal growing operation is underway, wherein the apparatus comprises a hollow delivery tube and a hollow storage cannister surronding the delivery tube. The hollow delivery tube comprises a side wall, an open upper end an an open lower end, and the hollow storage cannister comprises a side wall, an open upper end and a closed lower end, with the storage cannister's closed lower end having a central opening. The delivery tube and storage cannister are in concentric relation to one another, with the side wall of the delivery tube being received by and making a close sliding fit with the central opening in the storage cannister's closed lower end. The delivery tube's upper end resides inside the storage cannister while its lower end resides outside the storage cannister. A supply of source material for replenishing the melt is placed inside the storage cannister between the side wall of the delivery tube and the side wall of the storage cannister, and the lower end of the delivery tube is positioned directly over the melt which is to be replenished. During crystal growth, the storage cannister is moved in an upward direction relative to the delivery tube and as it does, source material in the cannister is carried upward above the upper end of the delivery tube and gravity causes it to automatically fall into the open upper end of the delivery tube which directs it into the melt.

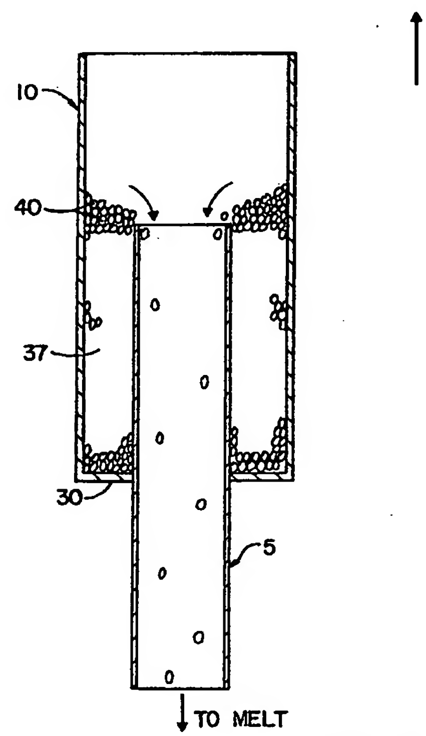

FIG. 2

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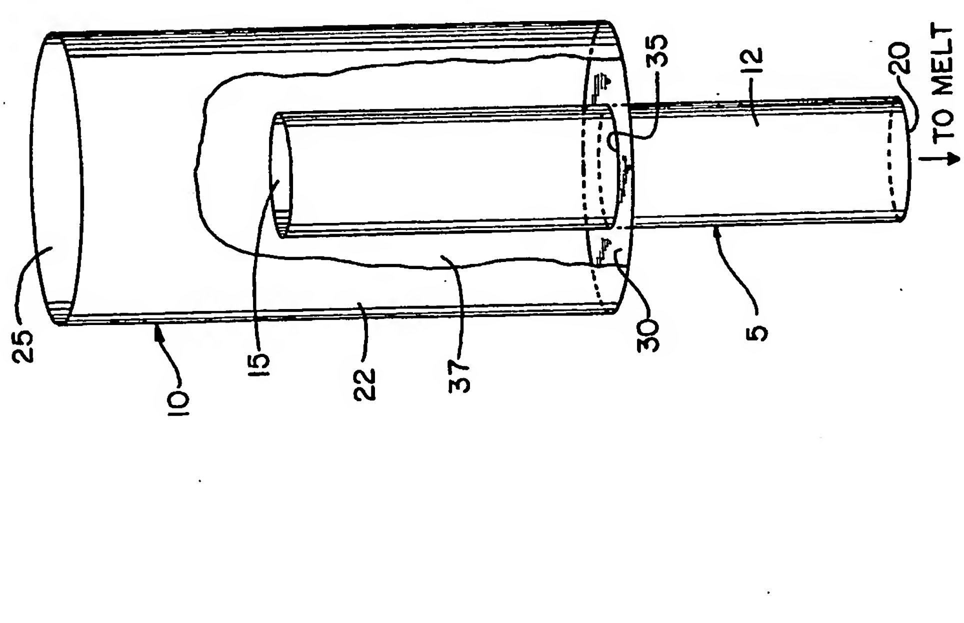

FIG. 1

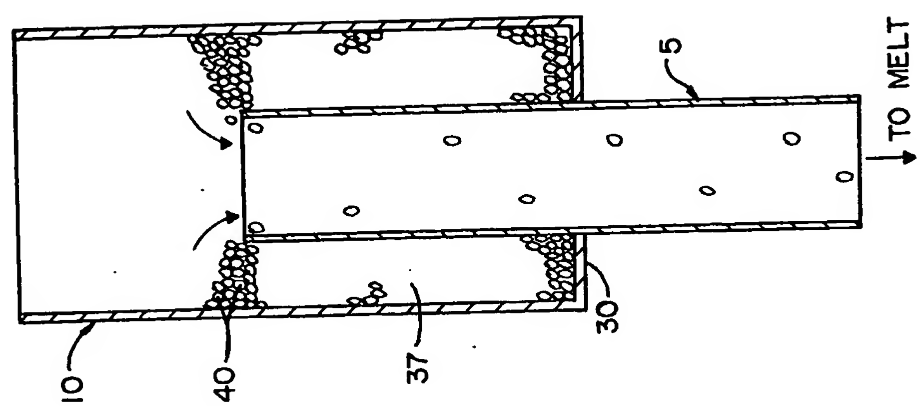

FIG. 2

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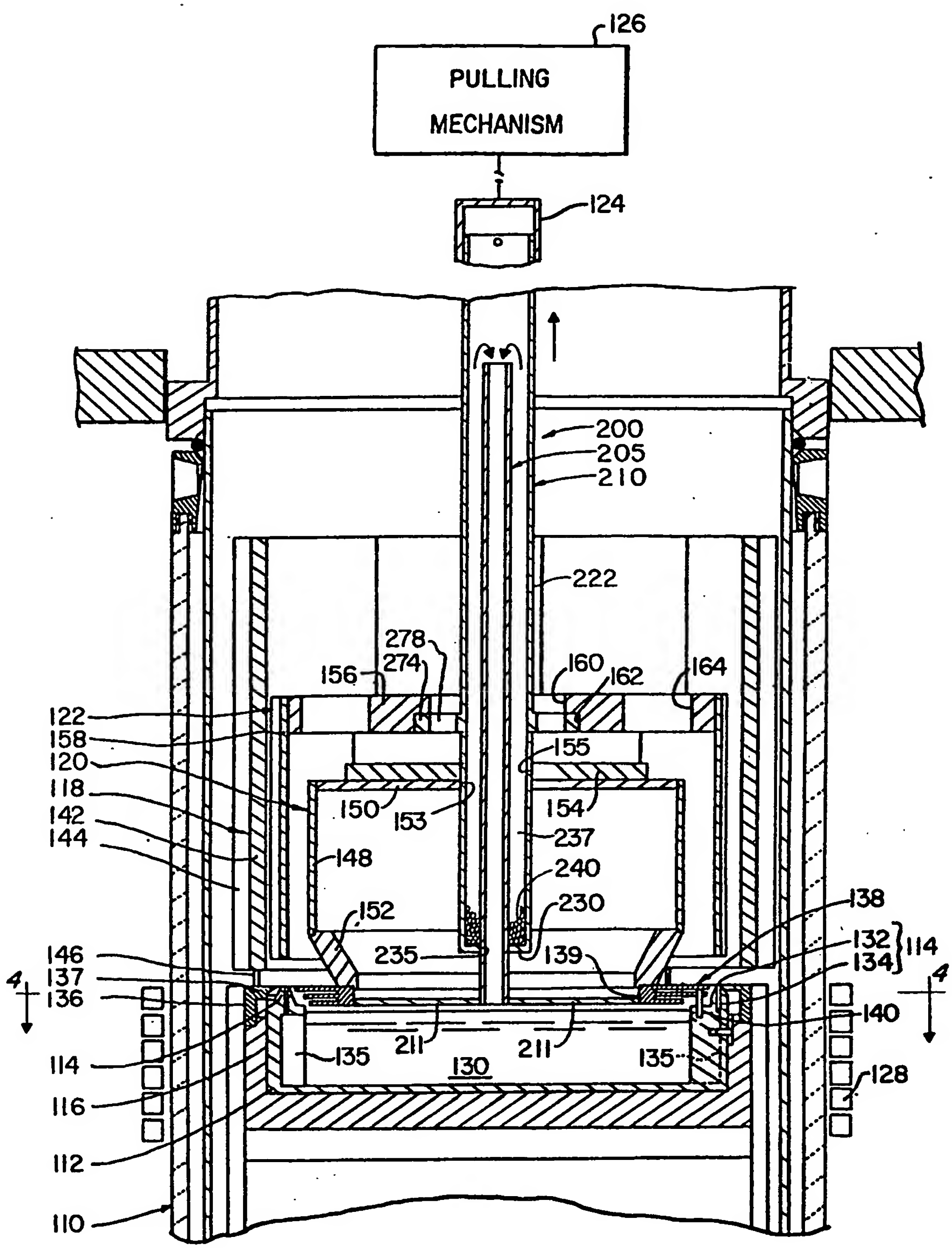

FIG. 3

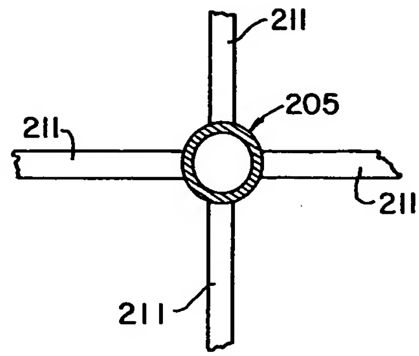

FIG. 4

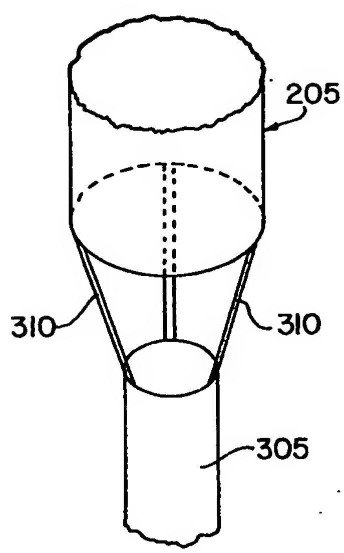

FIG. 5

SPECIFICATION

Apparatus for replenishing a melt

Field of the invention

This invention relates to apparatus for growing crystalline bodies from a melt, and more particularly to apparatus for replenishing a melt.

Background of the invention

Various methods have been developed for growing crystalline bodies from a melt. One such method is known as the edge-defined, film-fed growth technique (also commonly called the EFG Process). Details of the EFG Process are described and illustrated in U.S. Patent No. 3591348 issued July 6, 1971 to Harold E. LaBelle, Jr. for "Method of Growing Crystalline Materials," and in U.S. Patent No. 3687633 issued August 29, 1972 to Harold E. LaBelle, Jr. et al. for "Apparatus for Growing Crystalline Bodies From The Melt".

In the EFG Process, a capillary-forming die member is placed in association with a melt of liquid source material so that a growth face on the die member is wetted with a liquid film of source material from the melt by capillary action. A product crystalline body is then grown by first introducing a seed crystal to the liquid film of source material so that crystal formation is initiated, and then drawing the seed crystal away from the growth face at a controlled rate so that the liquid film of source material remains sandwiched between the growing crystalline body and the growth face of the die member. Since the liquid film of source material on the die's growth surface is continuously replenished from the melt by the die's capillaries, continuous crystalline bodies of significant size may be grown from the melt.

One consequence of the foregoing process is that the liquid source material in the melt is consumed during the crystal growing operation. Heretofore, no reliable and effective means has been available for continuously feeding additional source material to the melt while EFG crystal growth is under way. Unless melt replenishment can be effected while growth is underway, the crystal growing operation must be shut down completely to permit the depleted melt to be replenished with additional source material.

Unfortunately, the need to shut down the crystal growing operation from time to time to replenish the melt raises certain problems. More particularly, shutting down (and starting up) an EFG crystal growing operation is time-consuming and expensive. In addition, having to shut down a crystal growing operation to replenish the melt affects the length of the crystalline body being grown. The maximum length of continuous crystal which can be grown is limited by the frequency with which crystal growing operation must be shut down to replenish the melt. Furthermore, starting up and shutting down a crystal growing operation requires the crystal growing system to settle into or depart from the optimum crystal growing conditions. During this period of system adjustment, the crystal grown may be of inferior quality to that normally produced. Unfortunately, design considerations tend to limit the maximum practical size of the crucible which holds the melt, and hence the maximum quantity of source material contained in the melt at startup.

Prior attempts at automatically feeding additional source material to a melt in a process involving a capillary die or equivalent growth shaping member have been unsatisfactory for a number of reasons, including excessive perturbation of the melt as additional source material enters the crucible, lack of reliability, excessive size, high cost, and complicating the design of adjacent equipment components.

Objects of the invention

Accordingly, the principal object of the present invention is to provide a novel means for replenishing a melt while a crystal growing operation is under way, so that the crystal growing operation can continue without interruption for longer periods of time.

Another object of the invention is to provide a new feeder apparatus for replenishing a melt which is adapted to replenish the melt at substantially the same rate at which the melt is consumed during a crystal growing operation.

Yet another object is to provide a feeder apparatus for replenishing a melt which is simple to construct, inexpensive to produce, and reliable to operate.

Still another object is to provide apparatus for replenishing the melt which can be used in conjunction with apparatus for growing crystalline bodies according to the EFG Process, as well as in conjunction with apparatus for growing crystalline bodies according to other processes.

And yet another object is to provide apparatus for replenishing the melt which is adapted to operate from a position inside a hollow crystalline body as the body is being grown from the melt.

Summary of the invention

These and other objects are achieved by the present invention which provides a novel apparatus for replenishing a melt comprising a hollow delivery tube and a hollow storage cannister surrounding the delivery tube. The hollow delivery tube comprises a side wall, an open upper end and an open lower end, and the hollow storage cannister comprises a side wall, an open upper end and a closed lower end, with the storage cannister's closed lower end having a central opening. The delivery tube and cannister are in concentric relation to one another, with the side wall of the delivery tube being received by and making a close sliding fit with the central opening in the storage cannister's closed lower end. The delivery tube's upper end resides inside the storage cannister while its lower end resides outside the storage cannister. A supply of source material for replenishing the melt is placed inside the storage cannister between the side wall of the delivery tube and the side wall of the storage cannister, and the lower end of the delivery tube is positioned over the melt which is to

be replenished. During crystal growth, the storage cannister is moved in an upward direction relative to the delivery tube and as it does, source material in the canister is carried upward above the upper end of the delivery tube and gravity causes it to automatically fall into the open upper end of the delivery tube which dikects it into the melt.

Brief description of the drawings

These and other objects and features of the present invention are more fully disclosed or rendered obvious in the following detailed description of the preferred embodiment, which is to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

Figure 1 is an oblique view with portions removed showing the preferred embodiment of the present invention;

Figure 2 is a sectional view in side elevation of the apparatus of Figure 1;

Figure 3 is a sectional view in side elevation showing how the present invention is incorporated into a typical EFG crystal growing apparatus;

Figure 4 is a partial sectional view taken along line 4-4 of Figure 3; and

Figure 5 is an oblique view showing an alternative way in which the present invention may be incorporated into a typical EFG crystal growing apparatus.

Detailed description of the preferred embodiment

Looking first at Figures 1 and 2, the preferred embodiment of the present invention generally comprises a hollow delivery tube 5 and a hollow storage cannister 10.

Delivery tube 5 is cylindrical, having a side wall 12, an open upper end 15 and an open lower end 20.

Storage cannister 10 is cylindrical, having a side wall 22, and an open upper end 25. Its lower end is closed off by an end wall 30. The cannister's inner diameter is significantly greater than the delivery tube's outer diameter. The lower end wall 30 has a circular center opening 35. Opening 35 is sized so that it has a diameter which is only slightly larger than the storage tube's outer diameter.

Delivery tube 5 and storage cannister 10 are united in a concentric, telescoping fashion with the delivery tube being received by and making a close sliding fit in opening 35 of storage cannister 10. The delivery tube's upper end 15 resides inside storage cannister 10, while the delivery tube's lower end 20 resides outside storage cannister 10. The delivery tube's side wall 12 and the cannister's side wall 22 together define a gap or region 37 therebetween. The region 37 forms a variable volume storage chamber. The volume of chamber 37 varies in accordance with movement of storage cannister 10 in an axial direction relative to delivery tube 5.

The foregoing apparatus is prepared for use by first fixing delivery tube 5 in place so that its open lower end 20 is positioned directly over the melt which is to be replenished. Then storage cannister 10 is positioned on delivery tube 5 so that a significant portion of the delivery tube's side wall 12 extends above the storage cannister's closed bottom end wall 30 in the manner shown in Figures 1 and 2. Then source material for replenishing the melt (typically in the form of small pellets or chips 40) is placed inside storage cannister 10 in a quantity to fill chamber 37, as shown in Figure 2. At the time of loading, cannister 10 is positioned to maximize the volume of chamber 37.

Source material 40 is subsequently introduced into the melt as required by moving storage cannister 10 in an upward direction relative to delivery tube 5. This action causes the level of source material 40 in chamber 37 to be raised above the level of the delivery tube's open upper end 15. As this occurs, gravity causes the uppermost source material in chamber 37 to spill over into the delivery tube's open upper end, whereupon it will fall along the tube into the melt located directly below the delivery tube's open bottom end 20 (see Figure 2). As storage cannister 10 continues to move upward, more of the source material in chamber 37 will spill over into tube 5 for delivery into the melt. Continuous upward movement of storage cannister 10 relative to delivery tube 5 will result in substantially continuous delivery of additional source material to the melt, until the source material contained in gap 37 is exhausted. Stopping movement of cannister 10 will stop inflow of additional source material to the melt.

By appropriately sizing the dimensions of delivery tube 5 and storage cannister 10, and also by appropriately regulating the rate at which cannister 10 is moved relative to tube 5, the aforementioned apparatus can be made to continuously feed additional source material to the melt at substantially the same rate at which the source material is consumed from the melt during a crystal growing operation.

Looking next at Figures 3 and 4, the present invention is shown incorporated into an EFG crystal growing apparatus. Except as will hereinafter be made clear, the apparatus for replenishing the melt is substantially the same as the apparatus shown in Figures 1 and 2 and described above, and the EFG crystal growing apparatus is substantially the same as the apparatus described and illustrated in the copending U.S. Patent Application of R.W. Stormont et al., Serial No. 289410, filed August 3, 1981 for "Apparatus for Growing Tubular Crystalline Bodies".

More particularly, the EFG crystal growing apparatus generally comprises a furnace enclosure 110, within which are disposed a crucible 112, a capillary die 114 formed in part by the crucible, a crucible heat susceptor 116, a pair of concentric, hollow after-heater assemblies 118 and 120, a seed assembly 122, and melt replenishing apparatus 200. As will hereinafter be described in further detail, part of melt replenishing apparatus 200 is movably supported by a stem 124 attached to a pulling mechanism 126. Furnace enclosure 110 is surrounded by a radio-frequency heating coil 128 which is coupled to a controllable radio-frequency

power supply (not shown) of conventional construction. In use, crucible 112 is loaded with an initial charge 130 of the source material which is to be grown (e.g. silicon, alpha-alumina, and the like).

In greater detail, furnace enclosure 110 is typically fabricated from a pair of concentric, spaced-apart cylindrical quartz tubes. Although not shown, it will be understood that furnace enclosure 110 is closed top and bottom to permit the atmosphere within the enclosure to be controlled.

Crucible 112 is a short, hollow, open-topped circular cylinder centrally disposed within enclosure 110. Crucible 112 is formed out of a material which is compatible with the material which is to be grown, e.g. in the event silicon ribbon is to be grown, crucible 112 is formed out of graphite.

Capillary die 114 is integral part of the side wall of crucible 112, as detailed in U.S. Patent No. 4230674. Die 114 is provided with an upper end face 132 shaped and dimensioned to control the form and size of the crystal being grown. Thus, for example, in plan view face 132 is a hollow, thin-walled regular polygon. End face 132 is further provided with a capillary gap 134 of similar form centered in the face. A plurality of elongate slots 135 are formed on the inside of the side wall of crucible 112, communicating between capillary gap 134 and the interior of the crucible, so that the melted charge 130 may flow to the capillary gap wherein it may rise by capillary action to replenish the material on face 132 as the crystal is grown. Like crucible 112, capillary die 114 is formed out of a material which is compatible with the material which is to be grown, e.g. in the event silicon ribbon is to be grown, capillary die 114 is formed out of graphite.

Heat susceptor 116 is typically a short, hollow, open-topped body shaped and dimensioned to snugly accommodate crucible 112. The height of susceptor 116 is chosen to permit capillary die 114 to project upward beyond the top of the susceptor. Susceptor 116 is fabricated out of a suitable material, the choice depending in part on the available excitation frequency of heating coil 128, and in part on the compatibilities of the various materials present within the furnace. In the case of growing a silicon body, susceptor 116 is made of graphite.

The top of heat susceptor 116 may be provided with an outer radiation shield 136 in the form of a thin-walled hollow body of similar shape and outside dimension as susceptor 116, and typically including an interior flange 137 of similar form as end face 132 of capillary die 114. Flange 137 is substantially coplanar with but separated from end face 132. Outer radiation shield 136 is preferably fabricated out of a suitable material,e.g. molybdenum in the case where silicon is being grown.

Mounted to the interior of capillary die 114 is an inner radiation shield 138. Inner radiation shield 138 typically comprises a plurality of graphite plates held together in parallel, spaced-apart, opposing relation. Radiation shield 138 is provided with a circular central aperture 139. Inner radiation shield 138 may be supported in spaced-apart relation from die 114 by a plurality of pins 140 disposed about the inner periphery of die 114.

After-heaters 118 and 120 are disposed above, and in concentric relation to, die end face 132. Outer after-heater 118 is of open-ended right prismatic form, with its bottom end face being shaped similar to but larger than the die end face 132, i.e., side faces of after-heater 118 are arranged parallel to the corresponding sides of the polygon formed by end face 132, and extend substantially normal to the plane of the end face 132. Typically, after-heater assembly 118 is a double-walled structure, comprising a graphite interior wall 142 and an external carbon felt insulating outer wall 144. After-heater 118 is supported clear of flange 137 on outer radiation shield 136 by a plurality of pins 146.

Inner after-heater 120 includes a cylindrical wall 148, a top plate 150, and a tapered bottom section 152. Cylindrical section 148 has an outside diameter smaller than that of a circle tangent to the inside edges of end face 132 of die 114. Top plate 150 has a central aperture 153 formed therein. Tapered section 152 is in the form of a hollow, open-ended conical frustum attached at its larger end to the bottom end of cylindrical section 148. The smaller end of tapered section 152 has a diameter substantially the same as central aperture 139 in inner radiation shield 138. With the exception of the top of inner after-heater 120, the walls of each section typically are of single walled construction. However, typically the top of inner after-heater 120 is of double-walled construction, with top plate 150 supporting a somewhat smaller diameter carbon felt insulation pad 154. Insulation pad 154 has a central aperture 155 which is the same as aperture 153 in top plate 150. Inner after-heater 120 is supported on the top of inner radiation shield 138 by tapered section 152. The cylindrical section 148 of the inner after-heater is disposed with its cylindrical axis substantially normal to the plane of end face 132.

Seed assembly 122 comprises a seed holder 156 and a seed 158. For growing silicon, seed holder 156 is made of graphite. Seed holder 156 is a plate of similar size and shape as the end face 132 of die 114. Seed holder 156 is provided with a center hole 160 and a counterbore 162. Seed holder 156 is provided with a plurality of radial apertures 164 for passage of gas.

Seed 158 preferably is a short section of a crystalline body previously grown using the same apparatus. The length of the seed 158 is chosen to be greater than the overall height of the inner after-heater 120 by a dimension in excess of the thickness of seed holder 156. Seed 158 may be attached to seed holder 156 by graphite screws.

Melt replenishing apparatus 200 comprises a delivery tube 205 and a storage cannister 210. Delivery tube 205 and storage cannister 210 are formed out of a material which is compatible with the material which is to be grown, e.g. in the event silicon ribbon is to be grown, tube 205 and cannister 210 are formed out of quartz and/or vitreous carbon. Delivery tube 205 has its bottom end fixed to inner radiation shield 138 by a plurality of graphite sup-

ports 211 (Figures 3 and 4), so that the delivery tube resides with its bottom end disposed directly above the melted charge 130 contained in crucible 112. Delivery tube 205 extends upwards substantially normal to the plane of the die's end face 132, through apertures 153 and 154 in plate 150 and pad 154, and through counterbore 162 and hole 160 in seed holder 156.

Storage cannister 210 is disposed in telescoping relation with delivery tube 205, in the manner previously described, so that a storage chamber 237 is defined between the outer surface of the delivery tube and the inner surface of the side wall of the storage cannister. Storage cannister 205 also extends substanitally normal to the plane of the die's end face 132 through apertures 153 and 155 in plate 150 and pad 154, and through counterbore 162 and bore 160 in seed holder 156. Storage cannister 210 is sized so that the outer surface of its side wall 222 makes a close sliding fit in plate 150 and pad 154. At the same time, cannister 210 is sized so its side wall 222 is substantially smaller in diameter than bore 160 of seed holder 156. However, cannister 210 also includes an external circular flange 274 located intermediate its length which makes a close fit in counterbore 162 of seed holder 156. Flange 274 has a plurality of vent apertures 278 disposed so as to be inside of bore 160. Flange 274 is located along the length of cannister 210 so that the distance between the flange and the cannister's closed bottom end 230 is somewhat less than the length of the seed plates 168, for reasons which will hereinafter be made clear. The top end of cannister 210 is removably attached to stem 124 by means well known in the art, e.g. by screws. Stem 124 is in turn attached to pulling mechanism 126 by means well known in the art. Consequently, when pulling mechanism 126 pulls stem 124 in an upward direction, storage cannister 210 will be caused to move upward relative to delivery tube 205 and crucible 112.

To assemble the aforementioned apparatus, seed 158 is first attached to seed holder 156. Cannister 210 is then passed through the center hole 160 of seed holder 156 so that flange 274 is seated in counterbore 162 and thereby supports seed holder 156. It is to be appreciated that when seed holder 156 is supported in this manner by flange 274, the bottom end of seed 158 extends below the closed bottom end 230 of cannister 210.

Thereafter, storage cannister 210 is slipped over delivery tube 205 and lowered until the bottom end of seed 158 is adjacent to be not engaging the die's top end face 132.

In this regard it will be appreciated that inasmuch as seed 158 is sized to extend below the bottom of seed holder 156 by a distance greater than the height of inner after-heater 120, seed 158 will contact die end face 132 before seed holder 156 contacts insulation pad 154 atop the after-heater. In addition, it will also be appreciated that on account of the particular positioning of flange 274 on cannister 210, seed 158 will contact die end face 132 before the cannister's closed bottom end 230 can contact supports 211 which extend between the bottom end of delivery tube 205 and inner radiation shield 138.

Source material 240 is then loaded into the chamber 237 until the source material is level with the top end of delivery tube 205.

The apparatus is then ready to commence crystal growth. (It is to be noted that at startup, the crucible is filled with source material to form the melt 130, and the material in chamber 137 is intended to replenish the initial charge in the crucible as it is consumed by crystal growth). The furnace is heated to melt the charge in the crucible. Die end face 232 is heated above the melting point of the material of seed 258 and then the seed is lowered into contact with die end face 132. The portion of the seed contacting the die will melt, thereby wetting the end face and connecting with the melt in capillary 134. Thereafter, pulling mechanism 126 is activated to raise stem 124 and, as a consequence thereof, storage cannister 210. As storage cannister 210 moves upward along delivery tube 205, the engagement of its flange 274 with the seed holder causes the seed holder to be carried upward also. As the seed holder rises upward, seed 158 moves up away from the die, and the melted seed material wetting the die's end face is drawn by surface tension into a thin film between the seed and the die end face. As the seed holder continues to move away from the die end face, that portion of the liquid film nearest seed 158 begins to drop in temperature. More particularly, it starts to solidify as its temperature falls below the source material's melting point, thereby forming the desired crystalline structure. While this is occurring, the source material in melt 130 rises by capillary action to replenish the source material wetting the die end face, thereby allowing continuous crystalline growth to occur.

Simultaneous with this crystal growth, the upward movement of canister 210 causes source material in the storage chamber 237 to rise above the top of tube 205, whereupon gravity causes it to spill over into the delivery tube where it drops down into melt 130. The added solid source material liquifies under the continuous heating and becomes part of the melt. In this way, the melt is continually replenished by fresh source material, until the additional source material in the storage cannister is exhausted.

By coupling melt replenishing apparatus 200 to the same pulling mechanism 126 which withdraws the growing crystalline body from the die's end face, it is assured that the melt replenishing apparatus will automatically stop feeding additional source material to the melt if the crystal growing operation is temporarily halted. In addition, by appropriately sizing the dimensions of delivery tube 205 and storage cannister 210 relative to one another and also to the crystal growing furnace, the rate at which the apparatus replenishes the melt can be almost exactly matched to the rate at which source material is consumed from the melt, so that if the rate of crystal growth is incresed, the rate of feeding will automatically increase proportionally, and if the rate of crystal growth decreases, the rate

of feeding will automatically decrease proportionally.

By way of example, in the case where a 9" nonagon silicon crystal is being grown at a rate of about 1" per minute, it has been found that source material can be replaced at a substantially identical rate to its consumption by using a storage cannister with a 1.55" outer diameter (0.04" wall thickness), a delivery tube with a 0.98" outer diameter (0.04" wall thickness), and a 1" per minute upward pull rate on the cannister. By using a 28" long storage cannister and a 15" long delivery tube, enough additional source material can be added to the crucible to extend the time between shutdowns for recharging of the melt by approximately 300%.

Modifications of the preferred embodiment

It is to be appreciated that the preferred embodiment described above may be modified without departing from the scope of the present invention. Thus, for example, the delivery tube could be supported over the melt in a manner different than that shown in Figures 3 and 4. More particularly, as shown in Figure 5, the bottom end of the delivery tube could be attached to a support post 305 by a plurality of arms 310 forming a frusto-conical array, and the support post could have its bottom end fixed to the bottom surface of the crucible and rise perpendicularly upward therefrom. The source material falling down the delivery tube would fall between arms 310 and then into the melt. Of course, since in this arrangement at least part of support post 305 would be disposed directly in the melt, the post would have to be formed out of a material which is compatible with the material which is to be grown, e.g. in the event silicon ribbon is to be grown, support post 305 would be formed of graphite.

It is also contemplated that the delivery tube and storage cannister could be formed with cross-sectional shapes other than circular, e.g. they could be formed with polygonal cross-sectional shapes, or they could be formed with different cross-sectional shapes, e.g. one circular and the other polygonal. Of course, it will be appreciated that the center opening in the cannister's bottom end wall must have a shape corresponding to the cross-sectional shape of the delivery tube, so as to assure that the cannister's end wall will make a close sliding fit with the side wall of the delivery tube.

Of course, the invention does not require the use of a die 114 having an upper end surface in the shape of a regular polygon. Instead, the die could be adapted to grow a tube of circular cross-section.

It is also to be appreciated that the storage cannister could be pulled upward along the delivery tube by a pulling device separate from the device which pulls the seed holder upward.

It is also contemplated that the melt replenishing apparatus may be used in a manner different from the one disclosed above. Thus, it is contemplated that the same result may be achieved by maintaining the storage cannister fixed and moving the delivery tube downard relative to the storage cannister. Furthermore, it is contemplated that additional source material could be discharged from the melt replenishing apparatus by moving the storage cannister in an upward direction at the same time that the delivery tube is moved in a downward direction.

Still other changes of this type will be obvious to a person skilled in the art, and are considered to be within the scope of the present invention.

Advantages of the invention

Numerous advantages are obtained by using the present invention.

First, the present invention provides apparatus adapted to replenish a melt while a crystal growing operation is underway, so that the crystal growing operation can continue without interruption for longer periods of time.

Second, the present invention provides apparatus adapted to replenish the melt at substantially the same rate at which it is consumed during a crystal growing operation.

Third, the present invention provides apparatus for replenishing the melt which is simple to construct, inexpensive to produce, and reliable to operate.

The present invention can also be used with apparatus for growing crystalline bodies according to the EFG Process and also in conjunction with apparatus for growing crystalline bodies according to other known growth processes.

Another advantage is that the present invention provides apparatus which simultaneously (1) withdraws the growing crystalline body from the die's growth face and (2) replenishes the melt with additional source material.

Another significant advantage of the present invention is that the novel feeder is compact and adapted to operate from a position inside a growing hollow crystalline body.

Still other advantages will be obvious to persons skilled in the art.

CLAIMS

1. Apparatus for replenishing a melt comprising a hollow delivery tube and a hollow storage cannister,

said hollow delivery tube having a side wall, an open upper end and an open lower end, and

said hollow storage cannister having a side wall and an end wall closing off its lower end, said end wall having a central opening,

said delivery tube and said storage cannister residing in concentric and telescoping relation to one another so as to define an annular variable volume chamber between their side walls, said side wall of said delivery tube making a close sliding fit in said center opening, and said delivery tube having its open upper end residing inside said storage cannister, and its open lower end residing outside said storage cannister, whereby if additional source material for replenishing the melt is placed inside said chamber and said lower end of said delivery tube is positioned over a melt which is to be replenished, subsequent movement of said storage can-

nister in an upward direction relative to said delivery tube will cause source material in said chamber to spill over into the open upper end of said delivery tube whereby it will be directed by said delivery tube into said melt.

2. Apparatus according to claim 1 wherein said hollow delivery tube has a circular cross-section, and said opening in said storage cannister's lower end wall has a circular shape.

3. Apparatus according to claim 1 wherein said storage cannister has a circular cross-section.

4. Apparatus according to claim 1 wherein said delivery tube is supported above said melt by a plurality of supports fixed to a crucible containing said melt, said supports extending substantially radially from said delivery tube's side wall.

5. Apparatus according to claim 1 wherein said delivery tube is supported above said melt by a support post and a plurality of support arms, said support post extending vertically upward from the floor of the crucible containing said melt, and said plurality of support arms extending between said support post and said delivery tube.

6. Apparatus for use in growing crystalline bodies from a melt of selected source material, said apparatus comprising:

(a) a crucible for containing a supply of said source material;

(b) a crystal shaping member positioned within said crucible;

(c) means for heating said crucible;

(d) means for holding a seed and pulling said seed and a growing crystalline body away from said crystal shaping member; and

(e) means for supplying additional source material to said crucible so as to replenish said melt, said means comprising;

a hollow delivery tube having a side wall, an open upper end and an open lower end; and

a hollow storage cannister having a side wall and an end wall closing off its lower end, said end wall having a central opening therein;

said delivery tube and said storage cannister residing in concentric and telescoping relation to one another so as to define an annular, variable-volume chamber between their respective side walls, with said side wall of said delivery tube making a close sliding fit in said central opening, and said delivery tube having its open upper end residing inside said storage cannister and its open lower end residing outside said storage cannister and located over said crucible, whereby if additional source material for replenishing said melt is disposed inside said chamber, movement of said storage cannister in an upward direction relative to said delivery tube will cause the source material in said chamber to spill over into said open upper end of said delivery tube whereby it will be directed by said delivery tube into said crucible.

7. Apparatus according to claim 6 wherein said pulling means is arranged so as to move said storage cannister in an upward direction relative to said delivery tube as said pulling means pulls a seed away from said crystal shaping member.

8. Apparatus according to claim 6 wherein said pulling means comprises seed holding means adapted to support a hollow elongate seed which extends around said delivery tube and said storage cannister.

9. Apparatus for replenishing a melt substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

10. Apparatus for use in growing crystalline bodies from a melt of selected source material, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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